Gold Bursting Discs for the Protection of Chemical Plant

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The great advantages of bursting discs over the traditional safety valve have led to their widespread use in the process industries. The exceptionally high resistance to corrosion of gold and its great ductility make it particularly useful for low pressure applications.

In almost all its industrial applications gold is used in the form of an alloy because of the low mechanical strength and very high ductility of the pure metal. One example of its use in pure form, however, is in the thin foils needed for the production of bursting discs in the protection of chemical plants.

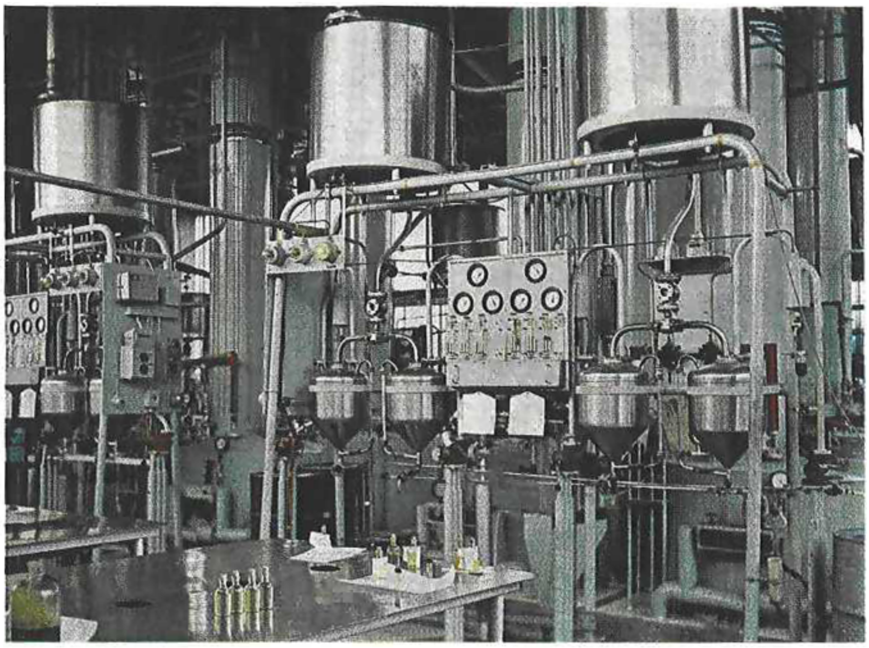
A bursting disc is a safety device which provides the simplest and most certain form of protection against the effects of excess pressure in a closed system. In any such system under pressure the use of a safety device is essential, and for many years the only method available was the safety valve.

By far the most commonly used device of this kind has an escape vent normally closed by a conically seated plug held in place either by a spring or a dead weight. When the internal pressure is sufficient to overcome the retaining force the valve plug is lifted allowing pressure relief.

While simple and robust, the safety valve has its limitations. It is difficult to obtain a leak-proof seating between the conical plug and the vent; the working parts are difficult to protect against corrosion, the seat may be stuck to the vent by resinous material, while its small relieving area and high inertia make it ineffective against explosions.

The use of a thin breakable membrane to overcome these disadvantages and to ensure the safe relief of excess internal pressure is now commonplace in chemical engineering systems.

Bursting discs provide the simplest and most certain form of protection against the effects of excess pressure in a closed system. They cannot fail to operate, they have very low inertia so that they open immediately to give a full-bore passage for the discharge of fluid to relieve overpressure. For corrosive conditions at relatively low pressures and temperatures, gold bursting discs are used. The illustration shows a gold disc with its capsule type holder and vacuum support



In this fractional distillation plant at Givaudan & Co. gold bursting discs are fitted to protect the system from excess pressure. Aromatic chemicals are produced for use in the perfumery industry, and the corrosive conditions can vary from batch to batch

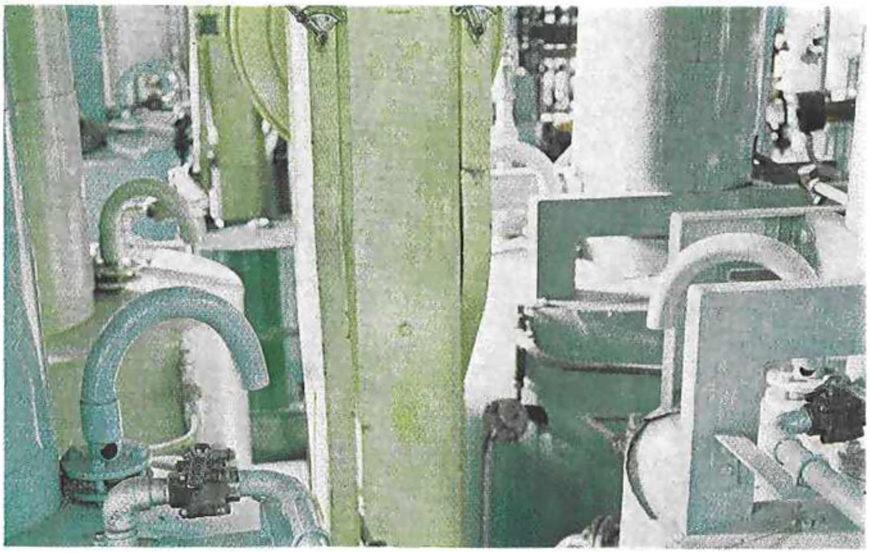
As a protection device, a bursting disc must successfully perform two functions; it must burst when the pressure in the system reaches a certain value, and it must withstand without rupture all lower pressures to which it may be subject during working.

If a bursting disc is to operate successfully it must be mounted in a correctly designed holder. The disc must be clamped between two smoothly machined flanges with an accurately machined radius on the edge of the orifice against which the disc bears.

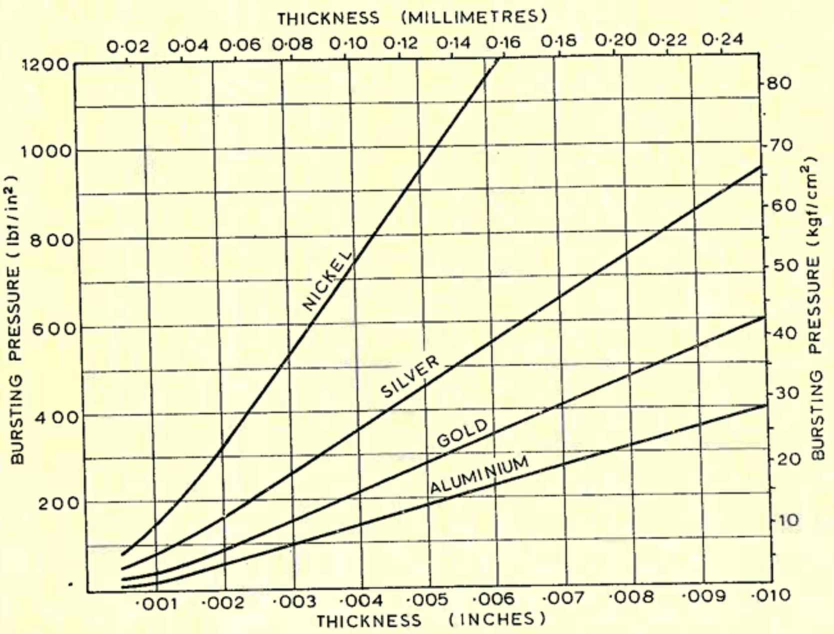
The holder flanges are dimensioned to fit neatly between the standard flanges used in the pipe-work of the system to be protected. Bursting discs operating at low pressures are not always able to withstand the effect of vacuum, and in cases where this condition arises a vacuum support is fitted beneath the disc to prevent collapse.

The relationship between the bursting pressure of a disc and its thickness is shown for a number of metals in the graph opposite. Most metals behave in a manner which reflects their characteristic tensile strength, and it can be seen that the more ductile metals are those best suited for use in low pressure discs.

The most commonly used bursting disc materials are nickel, aluminium and silver. Discs in these materials are used to protect pressure vessels in a wide variety of application but in all cases the corrosion conditions are established and do not vary. Any minor chemical attack that might cause pits or pin holes in the discs would soon render them useless. Great care must therefore be taken to select a disc material appropriate to the particular operating conditions.



The bursting disc assemblies in the Givaudan plant are mounted between flanges on the outlet pipes, which have observation holes cut in them to check whether a disc has burst. Close-fitting sleeves fit over the observation holes; these are shown raised on the two outlet pipes nearest to the camera



For a metal disc burst in tension the relationship between the thickness of foil T, the diameter of the orifice D in which the disc is burst and the bursting pressure T is given by the expression

$$\frac{DP}{T} = K$$

where K is a constant for a particular material. Thus a bursting disc can be designed to burst at a specific pressure by selecting a thickness of foil to suit a given size of orifice. This graph relates to a one inch orifice diameter

Gold bursting discs are of particular value where they protect plants which may be used for a number of different reactions on a batch-production basis. The intrinsic corrosion resistance of gold meets the wide range of chemical conditions encountered in the various processes, and thus only one type of disc need be fitted. The freedom from surface film formation that gold discs offer means that the plant can be easily cleaned between batches without risk of contaminants being retained in the vicinity of the disc.

The plant illustrated here is for the fractional distillation of a range of aromatic chemicals used in the preparation of perfumes. It is protected by gold bursting discs which withstand the differing sets of corrosive conditions. The freedom from corrosion ensures the plant is always adequately protected, that the products prepared in it are not contaminated either by metallic corrosion products or by residual products difficult to clean off the disc. Gold discs were chosen for these reasons, and also because, by comparison with ceramic or graphite discs, they provide much greater resistance to premature failure resulting from process vibrations or thermal shock, while after rupture they will not yield particles that might clog vent pipes or safety valves down-stream of the disc.

The complete resistance to corrosion that characterises gold has also been found useful in the protection of pressurised storage tanks over long periods of time. Gold discs fitted to liquid ammonia tanks, for example, have shown exceptionally long lives, measured in years rather than months, when the cheaper materials such as nickel were quickly found to corrode and fail. The catalytic inactivity of gold has also led to its selection as a disc material to protect low-pressure systems containing hydrogen peroxide where the catalytic activity of other metals had caused the peroxide to decompose.

The temperature at which a bursting disc must operate affects its performance because creep—plastic flow under a continually applied stress less than that required to cause fracture—is a property strongly influenced by temperature. The creep-resistance of gold falls fairly rapidly with rising temperatures, and gold discs are not therefore recommended for use above 80°C. This property can, however, be taken advantage of in protection against fire. A system fitted with gold discs operating under pressure at ambient temperature was protected from the dangerous effects of overheating from the outbreak of fire because the gold discs decreased in bursting pressure to the level of the operating pressure as the disc temperature rose to 100°C.

The use of a gold bursting disc to protect systems operated under pressure ensures that the system is leak-proof because the metal is ductile enough for the disc flange to act as its own sealing gasket. As with any bursting disc, those made of gold ensure that any abnormal working conditions or incorrect assembly will cause the disc to fail safe. Gold discs are simple to install, and can be designed to burst at a specified pressure with a tolerance of no more than 5 per cent by choosing a thickness of foil to suit a given size of orifice.